



This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

- + *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
- + *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
- + *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
- + *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at <http://books.google.com/>

QE
101
A5
no.24

UC-NRLF



B 3 766 446

LIBRARY
OF THE
UNIVERSITY OF CALIFORNIA.

RECEIVED BY EXCHANGE

Class

426

GEOLOGICAL SURVEY OF GEORGIA

S. W. McCALLIE, State Geologist

BULLETIN No. 24

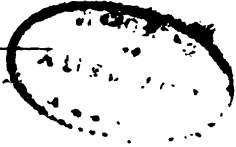
A SECOND REPORT

ON THE

PUBLIC ROADS

OF

GEORGIA


BY

S. W. McCALLIE

State Geologist

**ATLANTA, GA.
CHAS. P. BYRD, State Printer
1910**

QE101
A5
no. 24

EARTH
SCIENCES
LIBRARY

THE ADVISORY BOARD
OF THE
Geological Survey of Georgia
In the Year 1910

(Ex-Officio)

HIS EXCELLENCY, JOSEPH M. BROWN, Governor of Georgia
PRESIDENT OF THE BOARD

HON. PHILIP COOK-----**Secretary of State**
HON. J. P. BROWN-----**State Treasurer**
HON. W. A. WRIGHT-----**Comptroller-General**
HON. JOHN C. HART-----**Attorney-General**
HON. T. G. HUDSON-----**Commissioner of Agriculture**
HON. J. M. POUND-----**Commissioner of Public Schools**

LETTER OF TRANSMITTAL

GEOLOGICAL SURVEY OF GEORGIA,

ATLANTA, June 15, 1910.

To His Excellency, JOSEPH M. BROWN, Governor, and President of the Advisory Board of the Geological Survey of Georgia.

SIR: I have the honor to submit herewith a second report on the Public Roads of Georgia, to be published as Bulletin No. 24, of this Survey.

Very respectfully yours,

S. W. McCallie,

State Geologist.

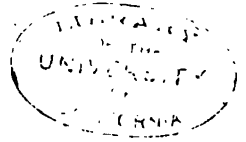
TABLE OF CONTENTS

	Page
PREFATORY NOTE.....	9
MILEAGE, EXPENDITURES AND OTHER PUBLIC ROAD DATA.....	11-16
ROAD-BUILDING MATERIALS OF GEORGIA.....	17-23
Road-building materials of the Paleozoic area.....	17-20
Knox dolomite.....	17-18
Chickamauga limestone.....	18
Bangor limestone.....	18
Chert.....	18-19
Shale.....	19
Sandstone.....	19-20
Road-building materials of the Crystalline area.....	20-22
Granites.....	20
Gneiss.....	20-21
Diorite.....	21
Trap or diabase.....	21-22
Road-building materials of the Coastal Plain.....	22-23
Limestone.....	22
Gravel.....	23
Clay.....	23
ROAD CONSTRUCTION.....	23-37
Location of roads.....	23-25
Grades.....	25-26
Drainage.....	26-28
Road Surfaces.....	28-37
Stone.....	28-30
Gravel.....	30-31
Sand-clay.....	31-37

PREFATORY NOTE

In submitting this report on the public roads of Georgia to the public the writer wishes to express his thanks to the State Prison Commission for valuable assistance in the co-operative work of collecting data on the roads of the State. Special thanks are also due to Capt. Goodloe H. Yancey, Secretary of the Prison Commission, who rendered invaluable aid in compiling the statistical data. In addition to the assistance here accredited, the writer wishes, furthermore, to express his gratitude to the various public road officials throughout the State for information concerning the public roads of their respective counties.

This report is the second report on the public roads of the State published by the State Geological Survey. The first report was issued in 1901. This report may, in a measure, be considered an abridged form of the report of 1901, with the addition of a large amount of statistical data brought up to date with additional matter added. It is to be regretted that the statistical data which were collected by correspondence with the county road officials had to be estimated, in many cases, however, they are thought to be sufficiently accurate to give a fairly trustworthy idea of the general conditions of the public roads of the State.



Public Roads of Georgia

MILEAGE AND EXPENDITURES

The statistical table of this report shows that the estimated public road mileage of the State of Georgia in 1909 was 82,182. Of this mileage, 554 miles were surfaced with stone and 56 with shells; 502 miles, with chert and gravel; and 3,421 miles, with sand-clay mixture. In addition to these more highly improved roads, there were also reported 13,156 miles of road which had been put in order by the use of the road machines, drags, etc. Omitting the 13,156 miles of roads which have been only partially improved, we still have a total of 4,533 miles of road surfaced with stone, shells, gravel, chert, and sand-clay mixture, which constitute about five per cent. of the total road mileage.

Of the 146 counties of the State, 107 employ convicts and 39 use statute or hired labor, the total number of convicts employed being 4,579.

The expenditures on public roads and bridges in 1909 were \$1,437,652 property tax, \$558,328 commutation tax and \$61,000 bond issue, a total cash expenditure of \$2,056,980. To this sum should be added \$450,000, the estimated money value of the statute and the free labor employed in the State on the public roads. This makes the grand total for all road expenses for the year \$2,506,980. In comparing the total road mileage of the State with the total estimated road expenditures it will be seen that each mile of public road cost last year \$30.51 or \$1.08 per inhabitant based on the census of 1900.

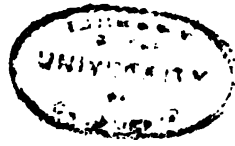
PUBLIC ROAD DATA OF GEORGIA COLLECTED BY THE STATE GEOLOGICAL SURVEY IN CO-OPERATION WITH THE STATE PRISON COMMISSION.

COUNTY	MILEAGE OF ROADS.			LABOR USED IN ROAD IMPROVEMENT.				Value of mules.	Value of road machinery.	EXPENDITURES FOR ROAD IMPROVEMENT			Total expenditures for roads and bridges.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
	Area sq. miles.	IMPROVED ROADS.			Total of all public roads.	Surfaced with stone or shells.	Surfaced with chert or gravel.			Surfaced with sand-clay mixtures.	Otherwise improved.	Average cost per mile.		Number of con-victs.	Salary of superin-tendent per month.	Salary of guards per month.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
		Total of all public roads.															Surfaced with stone or shells.	Surfaced with chert or gravel.	Surfaced with sand-clay mixtures.	Otherwise improved.	Average cost per mile.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
		IMPROVED ROADS.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	

¹ Estimate made on tax returns for 1908.

Clay	216	360		7	75 s-c	125	18	75	30	10	2,500	1,000		4,103	4,103
Clayton	142	300			30		48	70	30	27	6,000	3,000		2,620	3,120
Clinch	1077	400	10		100		34	40	25					3,000	3,000
Cobb	321	800	15	6	20 m	3,000	65	125	35	34	6,800	1,575	7,500	12,443	31,142
Coffee	920	950		30	6 s-c	400	42	60	30	20	5,000	300	6,000	7,366	13,366
Colquitt	565	700		7	400 s-c	300	26	60	30	14	3,500	800	2,000		6,500
Columbia	306	350			350 s-c	300	27	60	25	16	3,000	900	2,000		5,501
Coweta	443	800		25	150		56		30	26	6,000	2,500	8,000	3,591	37,593
Crawford	334	300			200		a	75	25	15	3,000	4,000	2,000	25,186	2,869
Crisp	255	450					23	75				135		6,745	8,745
Dade	188	145	10				a							2,327	2,327
Dawson	209	300					a								
Decatur	766	1,000		100	150	50	80	150	40	81	16,000	5,000	10,000	13,000	27,000
DeKalb	271	1,300	16	15	600	6,500	65	90	35	60	18,000	30,000	5,000	14,000	26,000
Dodge	495	450		25	350 s-c	350	25	75	20	16	4,000	2,000	6,000	7,248	18,684
Dooly	400	700			500		43	100	40	23	4,400	6,000	10,000	6,383	16,383
Dougherty	339	350	10		250		49	75	35	24	6,000	6,000	3,000	6,500	9,500
Douglas	212	400					a			6	1,300	260	1,960	3,500	5,460
Early	503	1,000		50	100 s-c	100	43	75	35	20	4,000	9,000	7,000	16,000	23,000
Echols	365	175					a								
Effingham	419	500					20	75	30	4	1,030	750	3,000	5,600	8,600
Elbert	388	700		20	100 s-c	1,400	34	50	30	22	5,000	3,000	7,500	6,000	13,500
Emanuel	776	1,000		40	250 s-c	250	36	45	25	24	6,000	1,500	8,000	18,000	28,000
Fannin	390	200					a								
Fayette	215	300			30	760	20	45	25	8	1,400	600	700	2,438	3,991
Floyd	506	800	100				53	166	50	64	14,400	16,000	11,000	22,118	43,515
Forayth	252	600					a								
Franklin	281	500		1	17	100	20	75	35	16	3,600			4,886	9,772
Fulton	174	400	300		25		539	300	37	235	58,750	40,000	8,000	210,000	218,000
Gilmer	450	1,000					a							842	3,842
Glascok	95	200		50		30		35		6	1,200	350	2,100	1,100	3,200
Glynn	468	150	20		s	2,000	39	100	50	4	400		2,300	6,581	8,881
Gordon	387	400					a							6,000	6,000
Grady	453	400					a								
Greene	850	400	3	3		200	23	45	25	26	6,000	1,200	6,000	5,774	17,548
Gwinnett	510	1,000			35		63	60	40	27	5,400	1,000		29,635	34,574
Habersham	280	400					a			4	1,150	150	3,855	3,000	6,855
Hall	449	600	8			1,500	a			4	800	1,500	6,000	6,800	12,800

COUNTY	MILEAGE OF ROADS.				Area sq. miles	Total of all public roads.	IMPROVED ROADS.				LABOR USED IN ROAD IMPROVEMENT.				Value of mules.	Value of road machinery.	EXPENDITURES FOR ROAD IMPROVEMENT			Total expenditures for roads and bridges.
																	PROPERTY TAX.			
																	Communtation tax.			
	Buried with stone or shale.	Buried with dirt or gravel.	Surfaced with sand and clay.	Otherwise improved.			Average cost per mile. d	Number of con-victs.	Salary of super-tendent per month.	Salary of guards per month.	Number of mules on public roads.	For roads.	For bridges.							
Hancock	750		25	300	\$ 25	35	\$ 75	\$ 30	28	\$ 5,870	2,500	\$ 6,500	\$	\$ 2,000	\$ 8,500					
Haralson	500					a					3,000		4,831	4,831	4,831					
Harris	486					a					500									
Hart	257			25		24	50	30	12	2,400	700	4,600	3,750	3,750	12,100					
Henry	313		10			26	75	40	8	1,800	450	2,200	2,200	750	2,950					
Henry	337			30		32	100	30	21	4,600	1,100	7,500	6,549	12,281	26,330					
Houston	591			800	\$-c	40	75	30	26	5,000	1,500	4,000	7,000	5,000	16,000					
Irwin	459		45	25	\$-c	26	75	25	14	3,150	1,250	3,500	3,500	3,000	10,500					
Jackson	1,000		10	100	\$-c	32	75	35	19	5,000	2,500	12,000	10,108	10,108	32,216					
Jasper	410					a														
Jeff Davis	395			400	\$-c	29			30	6,200	1,200	6,000	9,000		15,000					
Jefferson	686		100			40	90	35	22	5,000	700	5,500	5,177	1,725	12,402					
Jenkins	400			130		34	100	30	16	2,400	1,020	2,766	4,183	2,384	9,333					
Johnson	258		35	110	\$-c	26	60	30	25	5,500	3,000	4,200	3,346	2,007	9,333					
Jones	397			100		58	100	30	41	10,000	2,000	11,000	5,883		16,883					
Laurens	791		65	95	\$-c	32	85	30	21	4,500	2,000	4,000	4,500	1,795	10,295					
Lee	436		10	200	\$-c	a							3,701		3,701					
Liberty	976			100		10	50	30	15	3,000	2,500	3,500	4,000		7,500					
Lincoln	290					54	85	25	28	6,000	1,500	2,500			2,500					
Lowndes	455		60			a									2,000					
Lumpkin	282												2,000		2,000					
Macon	392		15			40	125	30	26	5,000	1,000	4,100	10,882	4,000	18,982					
Madison	278			10		29	60	30	17	4,300	1,200	10,000	3,300	3,300	16,600					
Marion	344		25	50	\$-c	15	40		9	1,800		3,600	3,000		6,600					
McDuffie	258		100	25	\$-c	7	55	30	14	2,000	350	2,500	4,008		6,508					



McIntosh	429	150	5					a	60	2	300	75	463	1,207	1,670
Meriwether	544	1,400		50	10			44	100	26	7,000	2,000	10,000	7,000	17,000
Miller	275	280						11	100	10	2,800	450	4,500		4,500
Milton	147	250						a					3,000	600	3,600
Mitchell	542	600		30	200	s-c	200	41	65	36	8,500	2,000	10,000	14,000	24,000
Monroe	480	1,000						30	75	26	5,000	1,000	5,500	10,000	20,500
Montgomery	642	800			100			26	75	40	22	5,000	1,000	4,850	12,225
Morgan	346	1,000		250	500	s-c	300	32	60	25	6,500	1,000	6,000	4,850	12,225
Murray	352	250	20					a				250	4,000		4,022
Muscogee	255	400	25	50				93	100	35	40	10,000	3,500	33,396	36,896
Newton	259	250	15	15	11	s-c	500	28	60	22	7,500	2,500	3,500	8,701	16,551
Oconee	184	350		2				29	50	30	12	3,000	3,300	1,418	6,136
Oglethorpe	575	940	10	50	30	s-c	500	33	50	30	20	5,000	7,000	6,000	13,000
Paulding	329	700						a		12	2,700		6,600	6,000	12,600
Pickens	219	500						a							
Pierce	518	250		10	75	s-c	200	22	50	22	2	450	1,700	5,951	7,651
Pike	294	900						53	85	35	35	7,500	5,000	9,404	15,971
Polk	292	600						a	65		27	6,750	2,010	11,000	11,000
Pulaski	477	580		50	250	s-c	22	38	100	40	31	8,525	1,500	10,000	18,500
Putnam	348	350	4	20	100	s-c	600	30	90	30	27	6,000	6,750	4,811	15,169
Quitman	152	250						a							
Rabun	344	400						a					4,000	2,000	6,000
Randolph	476	650		106				39	65	30	27	5,000	7,300	5,000	12,300
Richmond	272	900	7	80	100	g	1,600	168	100	40	70	14,000	10,000	64,000	64,900
Rockdale	121	238			5	s-cl	200	27	75	35	17	3,000	3,500	4,282	12,082
Schley	188	280						10	75	30	6	1,500	3,000	2,050	3,650
Screven	654	625		100	350	s-c	100	32	75	35	16	3,200	1,000	4,922	13,883
Spalding	203	1,000		5	22	s-c	250	68	75	35	16	4,000	2,500	5,500	26,953
Stephens	155	340		15		s-c	350	24	50	40	16	3,600	1,500	9,979	11,474
Stewart	440	690			13			32	90	25	16	3,000	2,500	8,688	11,688
Sumter	534	1,150		100		s-c	1,000	78	125	35	75	16,875	6,000	4,497	12,745
Talbot	407	414						a					6,500		50,000
Taliaferro	198	400						16	50	30	12	2,400	1,000	2,500	5,200
Tattnall	735	950		55		s-c	265	14	60	30	14	3,000	6,500	9,000	15,500
Taylor	338	350		5		s-c	400	a							
Telfair	412	400		50	100			30	75	25	14	3,500	1,500	5,616	14,828
Terrell	340	800		125	60	s-c	100	45	85	37	29	5,000	9,000	3,000	12,000

COUNTY.	MILEAGE OF ROADS.				LABOR USED IN ROAD IMPROVEMENT.				Value of mules.	Value of road machinery.	EXPENDITURES FOR ROAD IMPROVEMENT.			Total expenditures for roads and bridges.			
	Area agr. miles	IMPROVED ROADS.			Number of mules on public roads.	Value of mules.	Value of road machinery.	Commutation tax.			PROPERTY TAX.						
		Total of all public roads.	Surfaced with stone or shells.	Surfaced with chert or gravel.							Surfaced with sand-clay mixtures.	Otherwise improved.	Average cost per mile.		Number of con-victs.	Salary of superin-tendent or war-den per month.	Salary of Guards per month.
Thomas	504	600	50	300e-c	\$ 350	66	\$100	\$ 30	47	\$ 9,400	\$ 1,850	\$ 9,000	\$ 12,500	\$ 3,000	\$ 21,500		
Tift	271	350	90	40e-c	200	34	75	25	12	3,000	1,000	5,500	9,300	3,000	17,800		
Toombs	519	380	20	20		26	100	25	16	4,000	1,200	3,500	5,668		9,168		
Towns	168	150	15	15	e-c	600	a	30	19	4,000	2,105	6,322	11,550		17,872		
Troupe	434	650	100	200e-c	125	26	75	25	21	4,500	1,000	3,000	4,600	2,000	9,600		
Turner	326	800	150	150		25	100	30	14	3,500	1,000	4,600	1,929	964	7,493		
Twigg	423	300				a							723		723		
Union	325	200				a											
Upson	310	400				a											
Walker	433	563	234	42	800	a							10,000		10,000		
Walton	366	1,400		800		33	100	30	34	6,800	1,500		12,387	4,129	16,516		
Ware	676	300	8			31	75	35	10	2,000	11,500	2,500			2,500		
Warren	298	325		50		16	60	30	18	4,500	1,000	4,100			4,100		
Washington	680	1,200	200	50e-c	300	55	85	25	48	9,000	3,000	10,000	10,000	18,500	38,500		
Wayne	766	600	8	50e-c	500	a					5,700	2,500	5,106	2,042	9,648		
Webster	227	228	5	85e-c	1,500	10	65	35	10	2,500	500	5,000	2,629	4,331	11,960		
White	243	250				a							800		4,100		
Whitfield	285	450		150		a							8,000		8,000		
Wilcox	473	800				18	65	20	11	2,000	400	4,500			4,500		
Wilkes	501	900	6	100		34	60	30	22	4,000	3,000	6,470	6,918	2,421	15,809		
Wilkinson	431	500				20	40	25	9	2,200	1,500	5,000	2,641	3,301	10,942		
Worth	604	800		400		29	100	25	18	3,600	1,000	10,000	10,000	3,000	23,000		
Total		82,182	610	5023	421	13,156	4,579		2,645	588	450	271	480	558	328	1,157	
																895	
																2,056	
																980	

a-Roads kept up by statute or free labor or by both.
 roads partially improved by road machines, drags etc.
 m-Macadamized roads.
 e-c-Sand-clay roads.

b-Total expenditure, includes money raised by taxation and bond sale.
 d-The great variation in the cost of sand-clay roads is due to the width of roads, amount of grading, etc.
 g-Gravel roads.

c-Otherwise improved" are
 s-Shell roads.

ROAD-BUILDING MATERIALS¹

In the discussion of the road-building materials of Georgia, it is well to divide the State into three divisions, namely, the Paleozoic Area, the Coastal Plain, and the Crystalline Area.

ROAD-BUILDING MATERIALS OF THE PALEOZOIC
AREA

The road-building materials of the last named area, the Paleozoic, which comprises all or a part of ten counties in the northwestern part of the State, consist of limestones, cherts, shales and sandstones.

LIMESTONE.—The limestones of the area are very abundant and well suited for macadamizing purposes. They are divided geologically into three divisions, namely, the Knox dolomite, the Chickamauga limestone, and the Bangor limestone.

THE KNOX DOLOMITE is the most extensive of the three formations. It attains a thickness, in places, of more than 4,000 feet, and occurs in the form of a number of broad belts traversing the area in a northeast-southwest direction, giving rise, usually, to broad, rounded ridges. The formation consists largely of compact, heavy-bedded, light-gray magnesian limestone, often oolitic and always containing a considerable amount of siliceous material in the form of chert. Its uniform texture and its semi-crystalline structure will adapt it for macadamizing purposes. It would, indeed, be a difficult matter to find a calcareous deposit better adapted for road-material than some of the beds of this formation. The stone is easily quarried and is readily crushed by the rock breaker;

1. For a more complete discussion of the road materials of Georgia, see Bulletin No. 8 on Roads and Road Materials of Georgia, published by this Survey.

but it has, at the same time, sufficient toughness to form a durable wearing surface.

THE CHICKAMAUGA LIMESTONE overlies the Knox dolomite. It occurs in the form of narrow belts, more or less parallel and often valley forming. The formation is so-called from Chickamauga valley, where, in the neighborhood of Chickamauga Park, it reaches its greatest development. Its various beds differ considerably, both in physical structure and mineral composition. In its western exposure it is a blue, flaggy, highly fossiliferous limestone with some local variations of minor importance. The compact, blue variety of this stone makes an excellent macadam. It has been extensively used for this purpose both at Chattanooga and in Chickamauga Park. It makes a hard, smooth road surface, comparatively free from dust. The Chickamauga limestone varies from 1,000 to 1,800 feet in thickness and is the underlying rock in many of the narrow, fertile valleys in Northwest Georgia.

THE BANGOR LIMESTONE is a pure, dove-colored limestone, attaining a thickness of about 900 feet. It is highly fossiliferous and contains, in places, crinoid stems in great abundance. The formation is well exposed along the flanks of Pigeon and Lookout mountains. The extent of the area covered by this formation is limited mainly to the narrow belts at the base of the above named mountains; and, as a consequence, it will probably never become of very great importance in road construction. However, its use for macadam in the vicinity of Chattanooga shows that it is well suited for that purpose.

CHERT.—The chert deposits of the Paleozoic Area are quite extensive and are widely distributed throughout the area. They occur in two different geological formations, namely, the Knox dolomite and the Fort Payne chert, the latter being

the lowest member of the Carboniferous formation. The chert of the Knox dolomite is co-extensive with the dolomite itself, and is by far the more important deposit of the two, for road building material. It occurs in the dolomite in the form of nodules, and also in beds, frequently several feet in thickness. In the weathering of the dolomite, the chert remains as a residual product in the form of gray flinty nodules. This siliceous material frequently accumulates to the depth of many feet along the sides and slopes of ridges where it is often well exposed in railroad cuts. The chert is an impure variety of flint, frequently containing more or less calcareous material, and is readily crushed into sharp angular fragments. It has been extensively used for several years for surfacing roads and streets throughout North Georgia and Tennessee. The material is well suited for roads of light travel, but where the traffic is heavy it is inferior to limestone. It possesses an excellent binding quality, but after long drought and much travel it becomes somewhat dusty.

SHALE.—The shales of the Paleozoic Area are of but little economic importance as road-building materials; however, the shales in the vicinity of Rome have been used to a considerable extent for road surfacing. This material makes a fair road surface; but it is objectionable, on account of its rapid wear and dusty condition during the dry season, especially when there is much travel.

SANDSTONE.—The sandstones of the Paleozoic Area are confined chiefly to Pigeon, Sand, and Lookout mountains. They are known as the Walden sandstone and the Lookout sandstone. The former constitutes the surface rock of the above named mountains, while the latter forms the cliffs and escarpments along thier slopes. The aggregate thickness of the

formations is several hundred feet. These sandstones are so easily crushed that they are of but little value for road material.

THE ROAD-BUILDING MATERIALS OF THE CRYSTALLINE AREA

The road-building materials of the Crystalline Area consist of granite, gneiss, diorite, and trap rock.

GRANITE.—The granite is very generally distributed throughout the Crystalline Area where it occurs in the form of large intrusive masses in the gneisses and schists. These granitic masses often cover hundreds of acres, and occasionally, as in the case of Stone Mountain, form dome-shaped masses, having an elevation of several hundred feet above the surrounding country. In texture the granites differ widely. They vary from an exceedingly fine-grained, homogeneous, monumental stone to a very coarse-grained granite or pegmatite. The fine-grained varieties are quite extensively quarried at several localities in the State for building and monumental stone; and also for street paving purposes. The physical tests, which have been made on these granites, show that they have great strength, and are therefore among the best of this class of stone for road material.

GNEISS.—Gneiss is far more abundant in the Crystalline Area than granite; and, as a general rule, it is much more suitable for road material. The gneisses are divided into two varieties, namely, the true gneiss, made up of quartz, feldspar and mica, and the hornblende-gneiss, which contains, in addition to these minerals, hornblende as an essential constituent. Hornblende-gneiss is generally superior to the true gneiss for road purposes on account of its finer texture and greater toughness. It occurs, in places, throughout North Georgia, where it is found in narrow belts underlying the so-

called "red lands." The great amount of iron which the rock carries adds probably to its binding quality. It wears well and is comparatively free from dust. The true gneiss makes a fair road-surfacing material, when it is fine-grained and composed largely of quartz. Nevertheless, it is usually inferior to hornblende-gneiss.

DIORITE.—Diorite, which is more or less abundant throughout North Georgia, is a green or dark gray rock resembling very closely in general appearance the hornblende-gneisses. It occurs mostly in the form of narrow belts or zones, intercalated with the gneisses and schists. Most of the diorites of the Crystalline Area have a schistose or laminated structure which injures it for road macadamizing purposes. The diorites, when fine-grained and not too distinctly laminated, make an admirable road material, second only to diabase. The toughness, hardness and binding quality of this stone are all excellent. Large exposures of this rock are to be seen throughout the Piedmont Plateau.

TRAP OR DIABASE.—Trap rock is very generally distributed throughout the Crystalline Area. It occurs always in the form of dikes, which have originated from the filling of fissures by molten matter forced up from below. The dikes have generally northwest-southeast trend and a nearly vertical dip. They almost invariably cut the gneisses and the schists at a considerable angle, and rarely ever show any evidence of shearing or crust movement since their formation. All the larger dikes of Georgia, so far as known, are usually quite uniform in thickness, and frequently extend for many miles, with but few interruptions. A good example of one of the larger dikes is to be seen in a cut on the Central of Georgia Railway a few miles east of Newnan. This dike continues for about 65 miles in a southeasterly direction through Cow-

eta, Meriwether and Talbot counties, finally disappearing beneath the recent sands about four miles south of Talbotton. These rocks are of dark gray or black color, usually fine-grained and quite difficult to break with a hammer. As a road-surfacing material, this class of rocks has no equal. Its great hardness and its remarkable toughness make it an ideal road-building material.

THE ROAD-BUILDING MATERIALS OF THE COASTAL PLAIN

The road-building materials of the Coastal Plain are limestone, clay and gravel. In the vicinity of the coast, shells also have had limited use in road surfacing.

LIMESTONE.—The limestones of South Georgia outcrop at many points throughout the Coastal Plain. They are exposed most abundantly along the streams and in the vicinity of lime-sinks or lakes. They are also occasionally seen in the cuts of the various railroads traversing this part of the State. These limestones are usually soft and of a porous nature; though, occasionally, they become quite compact and are partly crystallized. The softer varieties, in places, consist mainly of fragments of shells and a limited amount of sand cemented together by a calcareous matrix. This class of limestone has been used to a limited extent for road and street surfacing both in South Georgia and Florida, where it seems to give general satisfaction. It readily cements into a compact, hardened surface, comparatively free from dust. This material has been used in the last few years on some of the streets in the city of Macon, where it has given fair results. The hard limestones of South Georgia appear to have had but little use, so far, in road construction; nevertheless, they are more or less widely distributed, and they seem to be fairly well adapted to that purpose.



GRAVEL.—Gravel deposits are quite plentiful along the northern border of the Coastal Plain, where they are often seen in thick beds outcropping beneath the superficial layers of sand. The pebbles are all water-worn, and evidently mark the limit of an old shore line. They are often cemented by ferruginous, sandy clays, and make excellent material for road surfacing. Many exposures of these gravel deposits are to be seen in the vicinity of Augusta, Milledgeville, Macon and Columbus. These gravel deposits are well exposed just across the Savannah River from Augusta, near the Charleston and Western Carolina Railway. At this point, the gravel has been extensively worked for the last few years and shipped to Augusta, Savannah and other points, where it is used for both street and road surfacing. The binding material of this gravel is a ferruginous, sandy clay, which readily hardens into a compact mass on being dampened and rolled, forming an excellent road surface, which is both durable and free from dust.

CLAY.—The clays of the Coastal Plain and the other divisions of the State are quite abundant and are well suited for mixing sand-clay roads. At nearly all points through the Coastal Plain, such clays can be found from one to three feet below the surface.

ROAD CONSTRUCTION¹

LOCATION OF ROADS

The first thing to be considered in the location of a new road is the topography of the section through which the road is to pass. Where topographic maps are to be had, they can be used to great advantage in locating the most practical line for the proposed road. When these maps are not accessible,

1. For a more complete discussion of road construction see Bulletin No. 8, Roads and Road Materials of Georgia, published by this Survey.

there must be a preliminary survey made, showing the location and trend of the streams and ridges, together with the relative positions of the objective points to be reached by the road. Having obtained this desired information, the road builder proceeds to locate the line of road which will best accommodate the traffic for which it is to be constructed. The easiest grades and the shortest distances, consistent with the cost of construction, together with conveniences and necessities of the community, all should receive due consideration before the line of road is permanently located.

As a general rule, in mountainous or hilly countries, the best and most important highways are located along streams or ridges. Each of these locations has its advantages and disadvantages. Ridge roads are often dry and easily drained, but the descent of these roads to the valleys below are likely to present difficult problems in securing practical grades. The location of roads along valleys, on the other hand, although they may serve to a better advantage a larger number of people, is frequently objectionable on account of the extra expense of keeping up bridges. Even if the line of road does not cross the main stream of the valley, there are always many small tributaries or deep gorges to be bridged.

One of the most important questions to be solved by the road builder in Georgia, is not so much the question of location of new roads as it is of changing the location of roads already in existence. This is especially true where the roads were originally laid out along lot lines or division boundaries between properties, regardless of grades and other conditions. These mistakes must be corrected, in a great measure, before it will be possible to construct first-class roads with easy grade, throughout the State, at anything like a reasonable cost. The road authorities of the several counties should by all means see to it that their roads are always prop-

erly located before attempting any permanent improvement. Such conditions as these practically prohibit the construction of good roads in many localities until they are re-located. Changing the location of established roads frequently presents a simple problem; but, at the same time, it may save hundreds of dollars per mile in the cost of grading.

GRADES

Grade, as used in highway construction, means the degree of inclination from the horizontal, or the slope of the road surface. The grade is usually expressed either in the form of a simple ratio, as, for example, 1:20, or terms of percentage. The ratio 1:20 indicates a rise of 1 foot in every 20, or a 5 per cent. grade.

The grade of a road should depend, in a large measure, upon the character of the traffic for which the road is to be constructed. If the traffic is heavy and the individual loads are large, it is always advisable to reduce the grade to the lowest possible minimum consistent with the cost of construction. Most road builders place the maximum grade of macadamized roads at 1:20. Such high grades as this, however, should be short, as they overstrain the team and render frequent stops necessary. The tractive force required to move a given load over a road with a grade of 1 to 30 is nearly three times as great as that required to move the same load over a level road. It is nearly always practicable to reduce the grade of a road to the above maximum limit, even in mountainous regions, by making the line of road sinuous or zig-zag, without greatly increasing the distance between the objective points or the cost of construction. A good example of a mountain road laid out on this plan is the newly constructed public highway extending from Dahlonga to Murrayville.

Besides reducing the efficiency of tractive force, steep grades also greatly increase the cost of keeping roads in repair. It is a well known law of running water, that its erosive power varies as the square of its velocity; it therefore follows that a slight increase in grade will greatly increase the effective force of this destructive agent. The extra expense in maintaining a road with high grades will frequently aggregate, in a short time, a sum sufficient to pay the entire expense of relocating the road.

DRAINAGE

Drainage is one of the most important questions which confronts the road builder. Unless a road is properly drained, it is practically impossible to keep it in first-class condition. Water must be removed from the roadway or it will sooner or later destroy the hardened surface and thus render the road imperfect. This is true, not only of common dirt roads, but also of macadamized roads.

Road drainage is divided into two divisions, namely, surface drainage and subdrainage. Surface drainage conducts the water which falls on the surface of the road into the side ditches or drainways, while the subdrainage removes the water from beneath the surface.

Surface drainage is accomplished by giving the surface of the roadway a slight inclination or slope from its center to its sides and is known as "crowning" the road.

The angle of the slope which the crown of the road should have depends largely upon the character of the surfacing material used; that is, the angle of slope should be greater for permeable, such as sandy clays, than for the more impermeable materials. The usual grade for the crown of a macadamized road is about 1 in 30; that is, a roadway 30 feet in width should be six inches higher at the center than at the

sides. The crown of a dirt road should be somewhat greater; but in no case should it be so great as to cause an undue lateral erosion of the surface from heavy rains. The water, as it flows from the surface of the roadway, should be received in properly constructed drains on either side of the road. These drains should have sufficient slope to conduct the water off as rapidly as it accumulates.

A road properly crowned and supplied with suitable side ditches needs no further drainage. In some instances, however, subdrainage is also necessary to secure the proper drainage. The object of subdrainage is not only to remove the water which may penetrate the surface from above, but also to draw off the water which, by lateral seepage, enters the roadbed from below. Subdrainage may be accomplished by the use of either side or central drains. Side drains may be open or closed, and should always have a depth of two feet or more below the surface of the roadway, and sufficient slope to carry off the water. Open drains perform the double office of carrying off both the surface and the underground waters; and, for this reason, they are often preferable to closed drains. These drains, however, on account of their depth and proximity to the roadway, are frequently dangerous and are therefore objectionable.

Closed drains are variously constructed. One of the simplest consists of a narrow, properly graded ditch, about two feet or more in depth, and partly filled with water-worn, rounded stones. In constructing a drain of this character, it is always advisable to place the largest stones on the bottom and the smallest on the top. Such an arrangement gives ample space at the bottom for the free circulation of the water and prevents the washing in of the earth from above. To guard more completely against the filling of the spaces between the stones by earth, it is often best to overlay them

with grass or straw before filling the upper part of the ditch with earth. Where stones are not to be had, a drain can be made of logs, poles, and brush, which will answer all practical purposes.

For a more detailed discussion of the question of sub-drainage, including cost, etc., the reader is referred to Bulletin No. 8, on Roads and Road-Building Materials of Georgia, published by this Survey.

ROAD SURFACES

The roadway having been properly graded and drained the next step is the preparation of the surface. This is accomplished by covering the roadbed to the depth of several inches with broken stones, or some other suitable material.

STONE.—When stone is used for this purpose, it is customary to prepare the roadbed by first giving it the proper grade and crown, after which the roller is passed over it until the surface is thoroughly consolidated and hardened. The surface, having been prepared as above described, is now ready to receive its covering of broken stones.

It is always best to place the broken stone on the prepared sub-grade surface in two or more layers, in order that it may be more completely consolidated by traffic or by the use of the roller. The total thickness of these layers should depend both on the character of the traffic for which the road is constructed and, to some extent also, upon the nature of the road foundation. If the traffic is heavy and the individual loads are large, the thickness of the road-covering should be greater than when the opposite conditions exist. Furthermore, even when the traffic is light, the road-covering should be increased in thickness wherever the foundation is unstable or insufficiently drained. The road coverings vary from 4 to 12 inches, an average, probably, being about seven inches.



The first layer of stones should be spread as evenly as possible over the prepared roadbed to the depth of three or four inches, and then thoroughly compacted by rolling. It is always desirable to have the stones as nearly cubical as possible; and, in no case, should they exceed two or three inches in their greatest dimensions. The more cubical the stones, other things being equal, the easier they are to become consolidated into a compact mass.

The first layer of stone having been compressed from about six inches to four inches, it is ready for the reception of the second layer. This layer of stone, in first-class roads, is usually, when consolidated, about three inches in thickness, and consists of fragments one and one-half inches and less, in diameter. As the layer constitutes the actual wearing surface of the road, it is essential that the stone used should be as hard and tough as possible.

The road covering is finally completed by placing on the surface a layer of binding material, one-half inch or more in thickness, which is sprinkled and continuously rolled until it becomes thoroughly consolidated. One of the best and most satisfactory materials to use as a binder is the chips and dust obtained by screening the broken stones. When such material is not at hand, small gravel, sand or loam will answer the purpose. The object of the thin superficial layer is to form an impervious covering for the roadbed, and, at the same time, to unite the fragments of stone into a perfect bond.

Having constructed the roadbed as above described, and given to its surface a sufficient crown to conduct the water quickly into the gutters or side ditches, we have an excellent country road, and one, if kept in proper repair, that will last for many years, even under heavy traffic. Such roads are

but little affected by the seasons, and they are as serviceable for traffic in winter as in summer.

GRAVEL.—Instead of broken stone, gravel is often used for surfacing material. The gravel used for this purpose may be either rounded or angular. The rounded pebbles are found in the greatest abundance along old coast lines or occupying the beds of streams. The angular pebbles, on the other hand, are the result of a peculiar disintegration of the parent rock, and frequently occur, in considerable beds mixed more or less with clay. The water-worn pebbles are usually quartz, or some other hard rock well suited for wear on a road surface. Intermingled with the rounded pebbles in the natural bed, is invariably to be found either sand or clay filling the interstices and forming a matrix, which binds the materials together. The value of a gravel as a road material depends, in a large measure, upon the nature and physical condition of the matrix. If the matrix consists of sand alone, no amount of rolling or traffic will suffice to compact the material into a hardened road covering; but if, on the contrary, the matrix is made up of a sandy clay, with considerable iron oxide, the material is readily consolidated and forms an excellent road surface. A fair idea of the binding quality of the matrix of a gravel bed can usually be obtained from an examination of the gravel pit. When the walls of the pit stand perpendicular for any length of time, without signs of disintegration from freezing or other physical cause, the material will be found in most cases to give satisfactory results on the roadway.

Angular, or what is usually called pit gravel, binds readily into a compact mass; and, on this account, it is commonly preferred to water-worn gravel. This kind of gravel always contains a considerable amount of clay, which should be separated from it by screening before it is put on the road. It is,

furthermore, desirable, in order to obtain a uniform and smooth surface, to remove all the stones having a greater diameter than two inches. When it is not convenient to screen the gravel, the larger stones may be readily removed with a rake, as they are distributed over the surface of the road. Before the gravel is placed in position, the roadbed should be properly prepared by giving it the necessary crown and by compacting its surface either by the roller or by traffic. The thickness of the gravel forming the road covering should be greater than that of broken stones. They should have a total thickness of eight or ten inches, and should be put on the prepared road surface in two or more layers, each layer being thoroughly rolled before the succeeding layer is placed in position.

One of the strongest arguments in favor of gravel roads is the cheapness of construction. If the gravel has to be transported only a short distance, this kind of road covering is inexpensive, and at the same time forms a road surface well suited for country roads, where the amount of traffic is light.

SAND-CLAY ROAD.—A sand-clay road is a road surfaced with a mixture of sand and clay in such a proportion that when the mixture is compacted it forms a firm surface suitable for traffic. Roads of this class have in the last few years attracted much attention throughout the Southern States by reason of their cheapness and suitability for common country highways. The sand-clay mixture may be either an artificial mixture or a natural mixture, but in either case, other things being equal, the relative proportions of the two different ingredients remain the same. It not infrequently happens that common earth roads have for long stretches the right proportioning of sand and clay to make a typical sand-

clay road, in which case it is only necessary to give them the proper drainage and grade to form them into first-class sand-clay roads. It must not be inferred from the above statement that any kind of clay is equally suitable for the construction of sand-clay roads. A clay, in order to give the best results, should be highly plastic, and at the same time it should shrink but little in drying. In addition to these two physical properties, the clay should also have good slaking qualities, otherwise it will form lumps and will not mix readily with the sand.

Many clays, especially the high grade kaolins and fire clays, possess but little plasticity and as a result give very unsatisfactory results when used in constructing sand-clay roads. A fair idea of the plasticity of a clay may be had by rolling out a small pencil of it between the fingers and note the degree to which it will bend before breaking.

Shrinkage is the amount of contraction which a clay undergoes in the process of drying. The shrinkage of the Georgia clays, as shown by a large number of tests made in the Survey laboratory, varies from 1 to 17 per cent. Before using a clay for sand-clay roads, it is always advisable to determine its shrinkage. This may be readily done by making the clay into small bricklets and noting the degree of shrinkage upon drying. A clay with a high shrinkage leads to cracking and breaking up of the surface during the process of drying and a corresponding expansion when again wet by rain, conditions highly detrimental to a good road surface.

The rate of slaking of a number of South Georgia's clays, together with the condition of the slaked product is shown by the following table:

SLAKING TESTS OF GEORGIA CLAYS¹

	Time	Degree of slaking
Paper clay, Georgia Kaolin Co.....	6	Min. fine powder
Paper clay, American Clay Co.....	3	min. fine powder
Paper clay, Atlanta Mining & Clay Co..	5	min. fine powder
Paper clay, Albion Kaolin Co.....	4	min. fine powder
Flint clay, Gibson		no slaking
Paper clay, Butler	4	min. pulverulent
Plastic white clay, Gibson.....	5	min. flaky
White clay, Perry	2½	min. lumpy
Fire clay, Copperas Bluff	2½	min. coarse granules
Fire clay, Carr's Station	7	min. flaky
White, plastic clay, J. T. Hatfield....	7	min. granular
White clay, Rico mine	4	min. complete
Pottery clay, I. Mandel	10	min. slightly mealy
Fuller's earth, Twiggs county	20	min. very fine flakes
White clay, Van Buren	6	min. fine powder
White clay, Carswell, McIntyre.....	3½	min. slightly granular
White clay, Chalker	5	min. coarse granules
White clay, Byron	5	min. coarse flakes
Terra cotta clay, Aragon.....		splits into coarse flakes, but does not show complete disintegration.

The above slaking tests were made by immersing one-inch cubes of clay, previously dried at a temperature of 212 degrees F., in 250 cubic centimeters of water. A slaking test of sufficient accuracy for road building clays may be made by dropping fragments of thoroughly dried clay into a glass of water and noting the rate and the degree of disintegration.

The relative proportion of sand and clay to be used in sand-clay roads may be determined by the following method as given by W. L. Spoon:¹

"Two ordinary glass tumblers of the same size are filled to the brim, one with the dry sand to be tested and the other with water. The water is then poured carefully from one glass into the sand in the other until it reaches the point of overflowing. The volume of water removed from the glass which was originally full of water can be taken as an ap-

1. For a more complete discussion of the physical properties of the Georgia clays, see the Report on the Clay Deposits of Georgia issued by this Survey.

1. Farmer's Bulletin No. 311, U. S. Department of Agriculture, page 10.

proximate measure of the voids in the unit volume of sand contained in the tumbler. A simple calculation will reduce this to percentage volume."

These various tests are only given to enable the road constructor in the beginning to get a rough idea of the material to be used in constructing his sand-clay surface. By making these simple tests and also by a critical study of the mixture in a natural sand-clay road, in a short time, the road builder learns to select the material with a fair degree of accuracy without the use of tests.

The methods of building sand-clay roads are variable, depending upon the character of the subsoil and the nature of the material to be used. In the case the subsoil consists of sand, the method of surfacing, after the roadway has been properly drained and graded, is to cover the roadbed with a layer of clay from six to eight inches in thickness in the center, thinning gradually to the outer edge to five inches or less. As each load of clay is dumped on the road it should be spread uniformly over the surface to the desired thickness. The surface is now ready for its coating of sand, which should be spread evenly over the surface. Where the clay is not too lumpy, the sand may be allowed to be worked into the clay by traffic, more being added from time to time as it is needed. This method of making a sand-clay road is quite slow, unless the materials are especially adapted for the purpose for which they are used. To hasten the process of mixing the sand and clay, often the harrow and the plow are resorted to. Where this is done, it is best to use the plow and harrow just after a rain, when the surface of the road is in such a condition that it readily works up into a thin mud.

In case the subsoil is clay, the road is first drained, graded and crowned, as before, when the surface is loosened up and

pulverized by the plow and the harrow to a depth of about four inches. It is then covered to a depth of six or seven inches with sand, after which the sand and clay are mixed dry by harrowing. To get the best results, the road surface should be again mixed and puddled after a rain and then given the proper crown by a road machine or a drag.

These methods are usually employed when the sand-clay road surface is an artificial mixture, but when the sand-clay is a natural mixture the method is somewhat different. The method of constructing sand-clay roads with a natural sand-clay mixture, as adopted in Clarke county, and described by Prof. C. M. Strahan¹ in the Engineering Annual of the University of Georgia, is here given:

“First. The grading of the road bed is first done to a width of 30 feet.

“Second. In the center a bed of top soil 10 inches deep and 16 feet wide is laid. The teams haul over this bed as the work progresses. With clay foundation, it would be a mistake to prepare a trench to receive the top soil.

“Third. The road machine excavates flat-side ditches six inches deep and four feet wide; throwing the earth as a shoulder against the top soil bed, and then crowning the whole from ditch to ditch.

“Fourth. The construction teams and traffic pass over the green bed and pack it down chiefly in the center. When several hundred yards are thus partially packed, the road machine pulls in the material from the sides and resurfaces the bed. New top soil is delivered for weak places and shaped up.

“Fifth. As fast as the grading of the bed is finished, the

1. Engineering Annual, University of Georgia, Vol. IX, No. 10a, June, 1909, pp. 18-19.

top soil layer is spread on it. Thus by the time one-half mile of road has been graded and covered with top soil, the first one-fourth mile has undergone considerable packing and re-surfacing and getting into good shape.

"Sixth. For some weeks close attention is paid to the new bed, watching for weak places, doctoring them, maintaining the grade with new top soil and keeping the crown fully up to one inch per foot.

"Seventh. Wet weather hastens the period of consolidation if followed by a dry spell. When packed quite wet, the wheels consolidate the material from the bottom upward. In dry or moist weather, the top layer only is consolidated and may cut through at the next rain. A period of wet weather is usually necessary for a full packing down of the top soil into permanent firmness.

"Eighth. Usually, in two months, a new top soil road-bed is consolidated, shaped to its correct crown, and able thereafter to withstand the rains and the traffic. Much of the reshaping and doctoring of the surface coat is done at odd times incidental to the main grading work while the teams are in transit from barracks to the work."

The cost per mile to Clarke county of putting on this "top soil" coat, according to Prof. Strahan's estimate, using convict labor at 50 cents per day and the county teams at \$1.00 per day, is \$400.00.

The material which is used for road surfacing in Clarke county, designated as "top soil," is a residual sandy clay, resulting from the weathering of granites and granite-like rocks. It usually contains 50 per cent. or more of hard, coarse residue, consisting of quartz and feldspar, the latter often partially altered into kaolin. Experience shows that the best "top soil" is found in cultivated fields where the fine particles of mica are wanting and the clay has the essen-



tial plasticity. The results which have been obtained in Clarke county with the natural sand-clay mixture are very satisfactory, and the work fully demonstrates what can be done throughout the Crystalline Area region of Georgia where like material for building sand-clay roads is abundant.

A somewhat different material from the above natural sand-clay mixture has recently been extensively used in road construction in Sumter and other counties in South Georgia. The material here referred to is a reddish sandy clay widely distributed throughout the Coastal Plain. It, like the clays of the Crystalline Area, is often partially residual, having resulted from the weathering of the underlying formations. In Sumter county excellent results have been obtained by using the clay directly from the roadway without any previous mixture. The only attention necessary to keep these roads in first class condition, after they have been once properly graded and drained, is an occasional use of the split log drag, which fills up all ruts and washes and at the same time restores the former crown and leaves the surface in a smooth, even condition. These roads, which I had the pleasure of examining a few weeks ago, are what may be termed ideal country roads, over which from 8 to 10 bales of cotton may be drawn by a two-horse team with comparative ease. Such roads as those here referred to, namely, roads constructed of natural sand-clay mixture, may be found in a large number of other counties of South Georgia. In many places throughout this part of the State, it is true, surface sands occur, in which case artificial sand-clay mixtures must be resorted to, but, fortunately, even here only a few inches, or at most a foot or so, beneath the surface sands generally occurs an abundance of clay suitable for sand-clay mixtures.

BULLETINS OF THE GEOLOGICAL SURVEY OF GEORGIA.

1. Marbles of Georgia, by S. W. McCallie, 1894, 87 pp., 16 pl., and 2 maps. *Out of print.*
1. Marbles of Georgia, Second Edition, Revised and Enlarged, by S. W. McCallie, 1907, 126 pp., 52 pl., and 2 maps. *Postage, 13 cents.*
2. Corundum Deposits of Georgia, by Francis P. King, 1894, 133 pp., 6 pl., 1 map. *Postage, 9 cents.*
3. A Part of the Water-Powers of Georgia, by C. C. Anderson and B. M. Hall, 1896, 150 pp., 10 pl., and 2 maps. *Postage, 9 cents.*
4. A Part of the Gold Deposits of Georgia, by W. S. Yeates, S. W. McCallie and Francis P. King, 1896, 542 pp., 21 pl., and 1 map. *Out of print.*
5. A Part of the Phosphates and Marls of Georgia, by S. W. McCallie, 1896, 98 pp., 3 pl. *Postage, 7 cents.*
6. A Part of the Clays of Georgia, by Geo. E. Ladd, 1898, 204 pp., 17 pl. *Postage, 11 cents.*
7. Artesian-Well System of Georgia, by S. W. McCallie, 1898, 214 pp., 7 pl., and 2 maps. *Postage 13 cents.*
8. Roads and Road-Building Materials of Georgia, by S. W. McCallie, 1901, 264 pp., 27 pl., and 1 map. *Postage, 14 cents.*
9. A Part of the Granites and Gneisses of Georgia, by Thomas L. Watson, 1902, 367 pp., 32 pl., and 4 maps. *Postage, 21 cents.*
10. Iron Ores of Polk, Bartow and Floyd Counties, Georgia, by S. W. McCallie 1900, 190 pp., 8 pl., 1 map. *Postage 11 cents.*
11. Bauxite Deposits of Georgia, by Thos. L. Watson, 1904, 169 pp., 12 pl., and 1 map. *Postage 10 cents.*
12. Coal Deposits of Georgia, by S. W. McCallie, 1904, 121 pp., 14 pl., and 1 map. *Postage 9 cents.*
13. Ocher Deposits of Georgia, by Thos. L. Watson, 1906, 81 pp., 11 pl., and 3 maps. *Postage 6 cents.*
14. Manganese Deposits of Georgia, by Thomas L. Watson, 1908, 195 pp., 8 pl., and 2 maps. *Postage 12 cents.*
15. Underground Waters of Georgia, by S. W. McCallie, 1908, 376 pp., 29 pl., and 2 maps. *Postage 20 cents.*
16. Water-Powers of Georgia, by B. M. and M. R. Hall, 1908, 424 pp., 14 pl., and 1 map. *Postage 21 cents.*
17. Fossil Iron Ore Deposits of Georgia, by S. W. McCallie, 1908, 199 pp., 24 pl., and 3 maps. *Postage 14 cents.*
18. Clay Deposits of Georgia, by Otto Veatch, 1909, 453 pp., 32 pl., and 3 maps. *Postage 25 cents.*
19. Gold Deposits of Georgia, by S. P. Jones, 1909, 283 pp., 8 pl., and 2 maps. *Postage 16 cents.*
20. Mineral Waters of Georgia, by S. W. McCallie. *In preparation.*
21. Marls and Limestones of Georgia, by Otto Veatch. *In preparation.*
22. Brown Iron Ores of Georgia, by S. W. McCallie. *In preparation.*
23. Mineral Resources of Georgia, by S. W. McCallie, 1910, 208 pp., 20 pl., and 2 maps. *Postage 14 cents.*
24. Public Roads of Georgia, Second Report, by S. W. McCallie, 1910, 36 pages. *Postage 5 cents.*

NOTE.—For bound copies of Bulletins Nos. 1, Revised, and 6 to 23, inclusive, 3 cents additional postage will be required.



U.C. BERKELEY LIBRARIES



C033290919

